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DIPARTIMENTO DI ENERGIA

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Advanced Waste-to-Energy plant design for the enhanced production of electricity

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Research Center established at the end of 2010

MISSION: Establishing scientific bases for the many issues related to recovery from waste

Main goal: Give a rigorous scientific definition of the technologies and the policies which can be adopted for material and energy recovery, contributing to identify the most effective options for sustainable, economically viable waste management practices.

Support of public and industrial partners

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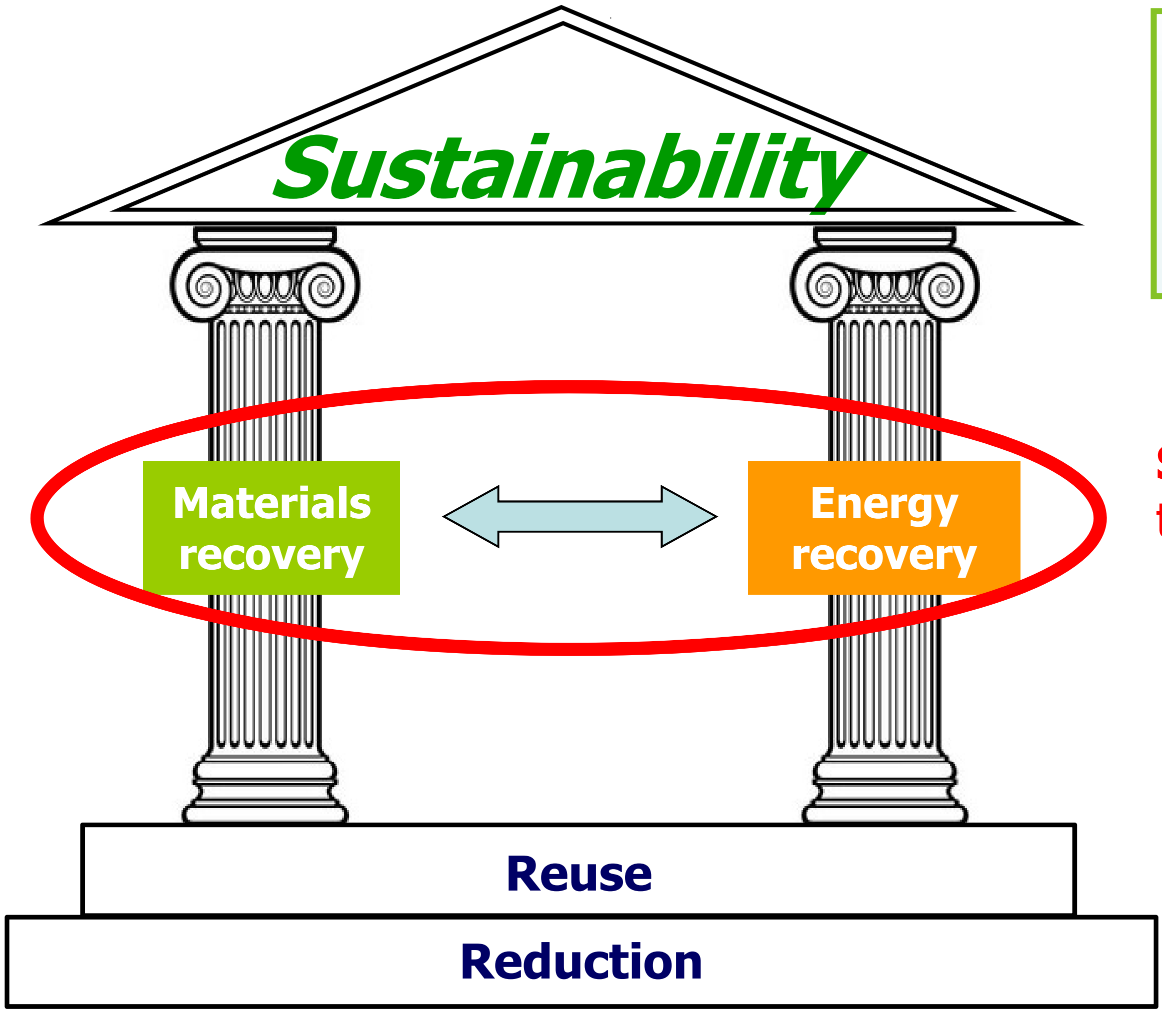
LGH LINEA GROUP HOLDING · Brianza Energia Ambiente · HestAmbiente Società del Gruppo Herambiente

MatER has established strong relationships with International research centers & Networks:

WTERT · ISWA International Solid Waste Association · ATIA ISWA ITALIA · PREWIN NETWORK

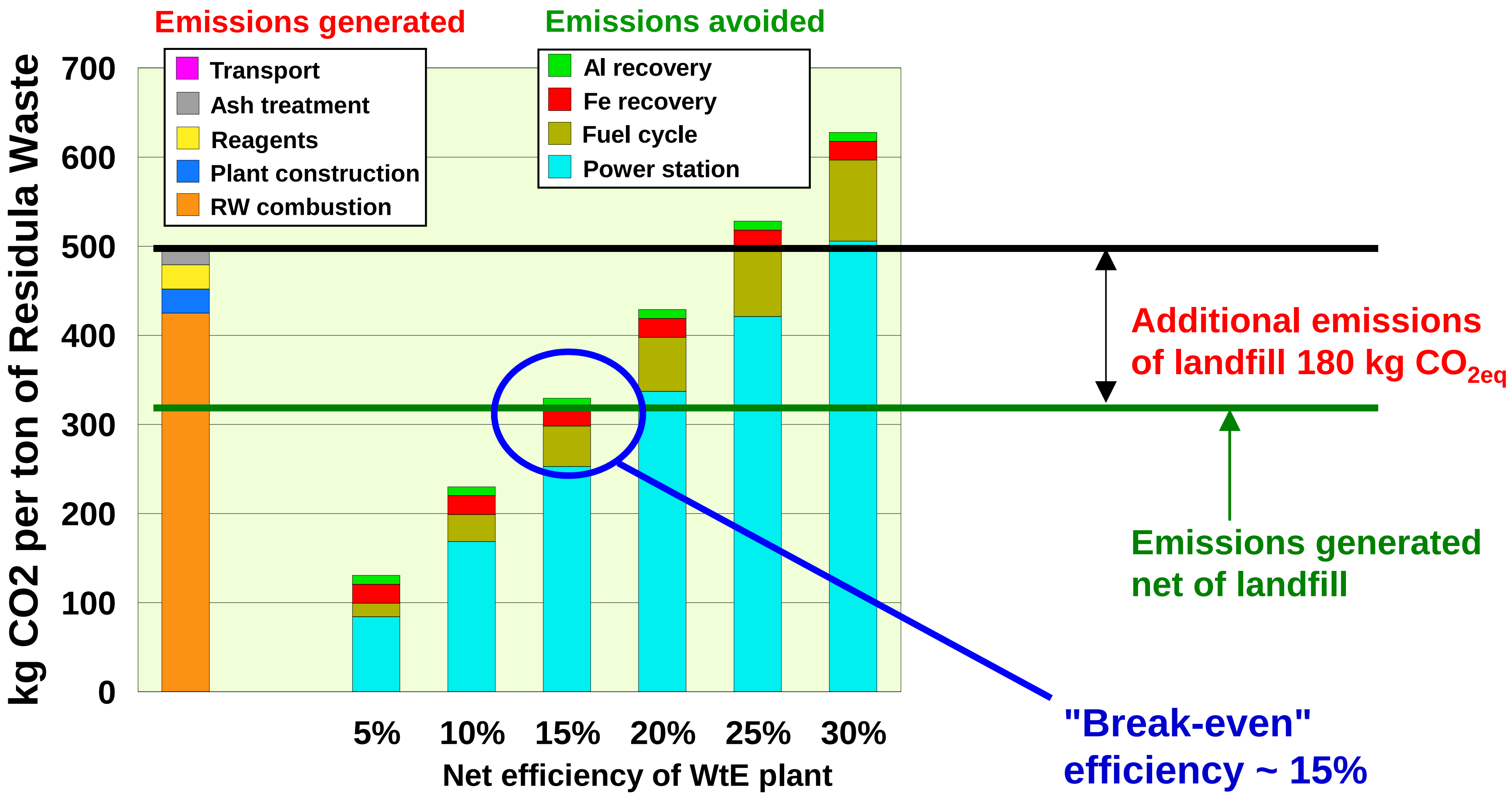


Materials and Energy recovery are <u>BOTH ESSENTIAL</u> for Sustainability

Strict interconnection between the two forms of recovery:

- Materials recovery generates residues that can be sent to energy recovery
- Energy recovery generates residues that can be sent to materials recovery

In LCA perspective, the performances of WtE are computed as balance between caused and avoided/replaced effects

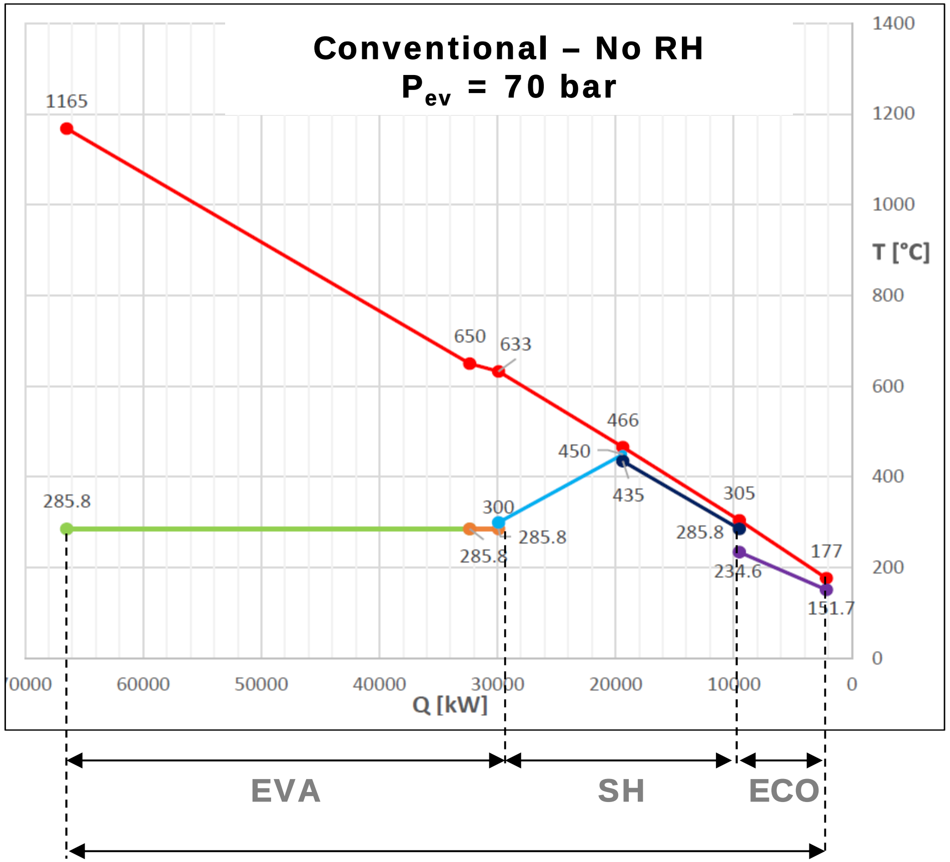


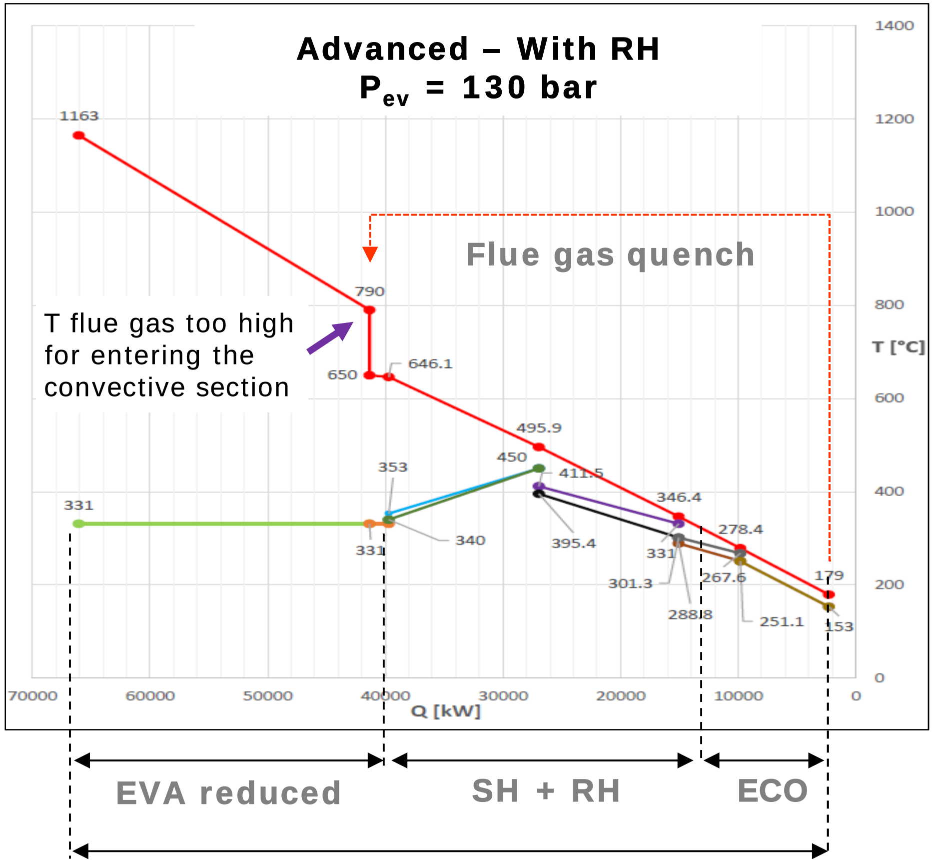
Which ways to increase efficiency?

1) Increase scale → larger plants
2) Improve steam cycle:
   - better cycle parameters → higher P_{ev}, T_{SH}, lower P_{cond}
   - more sophisticated configuration → more regenerators, reheat
3) Use auxiliary, high-quality fuels in complex, integrated configuration

- Plant size depends on collection area, permits, etc.
- P_{cond} depends on ambient conditions, water availability
- Higher P_{ev} necessarily requires either higher T_{SH} or reheat to limit liquid fraction at steam turbine outlet
- T_{SH} is limited by corrosion problems
- Integrated configuration is constrained by electricity market

Reference to a large plant (combustion power = 200 MW_{LHV})
Introduction of steam reheat and increase of P_{ev}
Comparison against a conventional design
Same technological constraints adopted ($T_{SH/RH}$ ≤ 450°C)

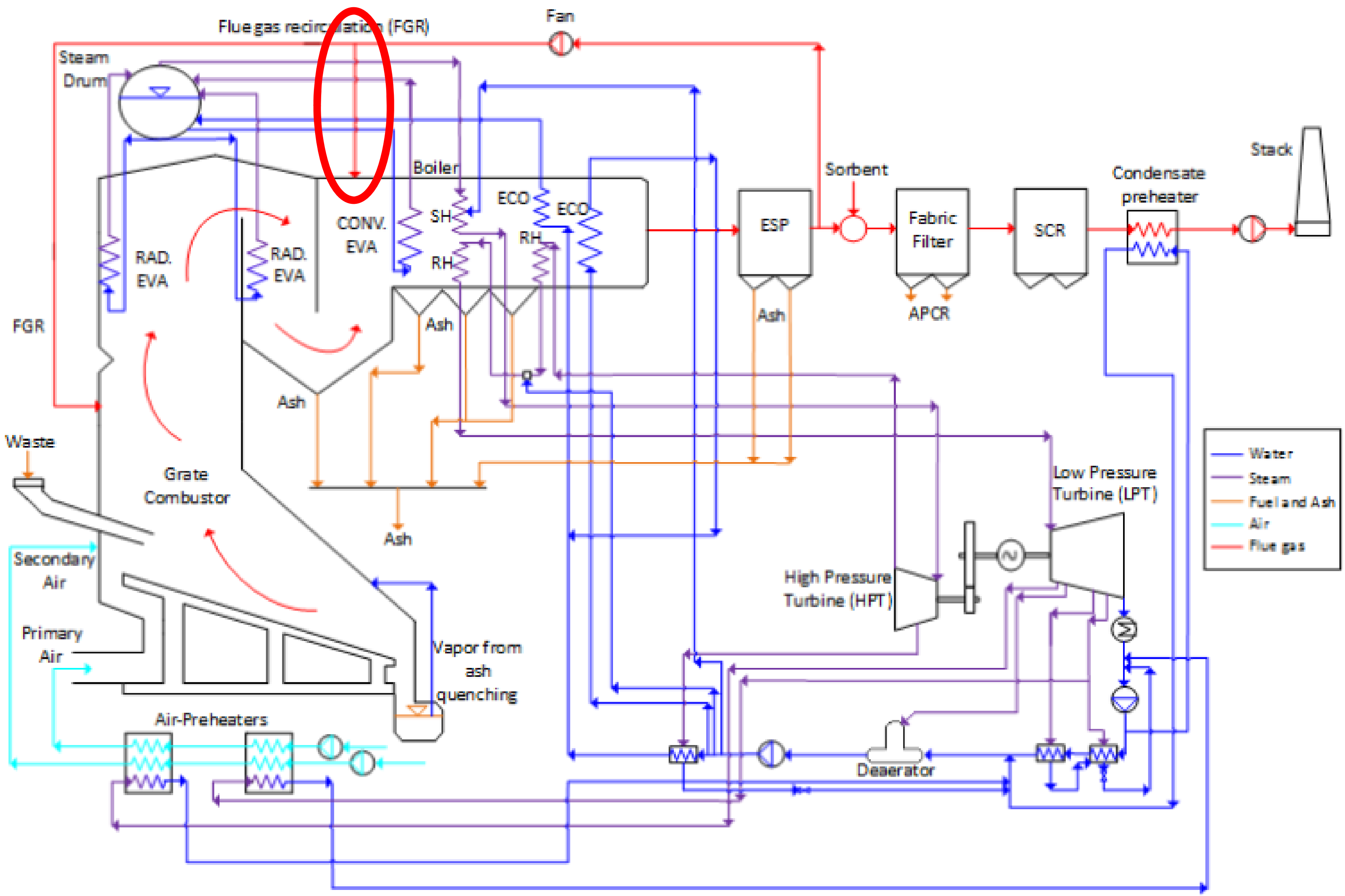




Same overall power exchanged

Same overall power exchanged

Advanced design – plant configuration



Assumptions and methodology

Design:	Conventional	Advanced
Combustion power – single line, MW_{LHV}	66.7	66.7
Number of parallel lines	3	3
Evaporating pressure, bar(a)	70.0	130.0
Superheating / Reheating temperature, °C	450/-	450/450
Reheating pressure, bar(a)	-	25.0
Condensing pressure, bar(a)	0.08	0.08

Combustors/boilers and steam cycle have been simulated by means of the commercial software **Thermoflex**

On-design and off-design simulations have been carried out to ensure proper sizing of the various components

In particular, the **minimum load (60%)** of the boilers without flue gas recirculation (FGR) in the secondary combustion zone is the most critical condition for the sizing of SH/RH, de-SH, and ECO

Investment costs have been evaluated based on the Thermoflex PEACE component, as well as on data from a boiler manufacturer

Results: sizing and performances

Design:	Conventional	Advanced
Gross power output (efficiency), MW ($\%_{LHV}$)	66.0 (33.0)	72.0 (36.0)
Net power output (efficiency), MW ($\%_{LHV}$)	59.6 (29.8)	65.0 (32.5)
Steam flowrate at HP turbine inlet, t/h	253.8	217.1
Projected area of waterwalls (EVA), m^2	2,450	1,480
of which refractory lined, m^2	*1,480*	*1,480*
of which Inconel 625 cladded, m^2	*653*	*403*
Area of screen EVA, m^2	137.2	83.0
Area of SH+RH, m^2	9,159	7,582
of which Inconel 625 cladded, m^2	*561*	*183*
Area of ECO, m^2	3,463	7,758
Overall (1 line) area of convective section, m^2	12,622	15,423

Moreover, the advanced configuration requires less civil works, because boilers, turbine and condenser are lighter

On the other hand, the advanced configuration requires an extra fan (for gas quench) and a larger ESP (ElectroStatic Precipitator)

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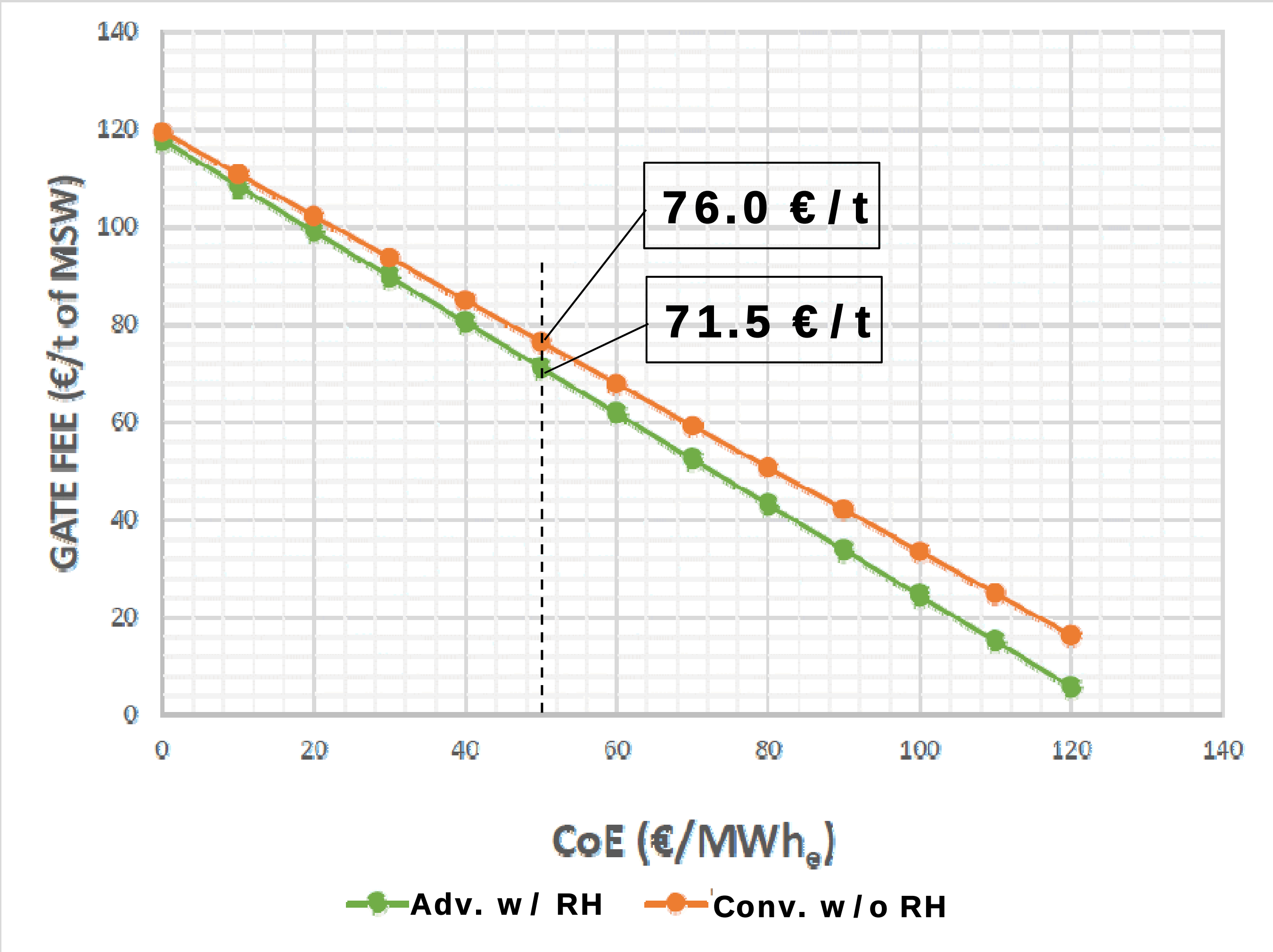
Total investment cost (overnight), €

Design:	Conventional	Advanced
Boilers and grates (3 lines)	144,253,338	140,203,704
Steam turbine assembly	17,155,000	15,567,000
Condenser and evaporating towers	4,557,277	4,211,394
Feedwater preheaters	477,490	537,682
Flue gas cleaning system (3 lines)	19,196,988	20,810,588
Deareator	386,430	363,109
Auxiliaries	1,722,653	2,262,347
Condensate and air preheaters	501,291	501,291
Waste feeding system	5,000,000	5,000,000
Ash handling system	4,000,000	4,000,000
Balance Of Plant (BOP = 6% of all the above)	11,834,610	11,607,427
Total Plant Cost (TPC)	**209,078,105**	**205,064,542**
Contingencies (5% of TPC)	10,453,905	10,253,227
Design, testing, insurance, safety (7.5% of TPC)	15,680,858	15,379,841
Total investment cost	**235,212,868**	**230,697,610**

Gate fee vs. Cost Of Electricity (COE)



8,000 eq. working hours per year

Capital Charge Ratio (CCR) = 15%

Annual O&M = 2% of TPC

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Higher efficiency & lower capital costs → better economics

Conclusions

- WtE with RH, thanks to “flue gas quench”, appears as a viable option to enhance the production of electricity
- Such a result is achieved by abiding all the state-of-the-art technological constraints (especially those on corrosion)
- Some refinements of these results are still ongoing with the collaboration of a boiler manufacturer. They include:
  - extending the operating range to 110% overload
  - considering clean / fouled conditions
  - adopting a more sophisticated design to reduce the required area of SH/RH and ECO, especially for the conventional configuration
- However, the final gate fee for the advanced configuration should remain of the same order of that for the conventional one, therefore confirming the economic feasibility
- From the energy/environmental standpoint the advanced configuration is, of course, superior

THANKS FOR YOUR ATTENTION!!

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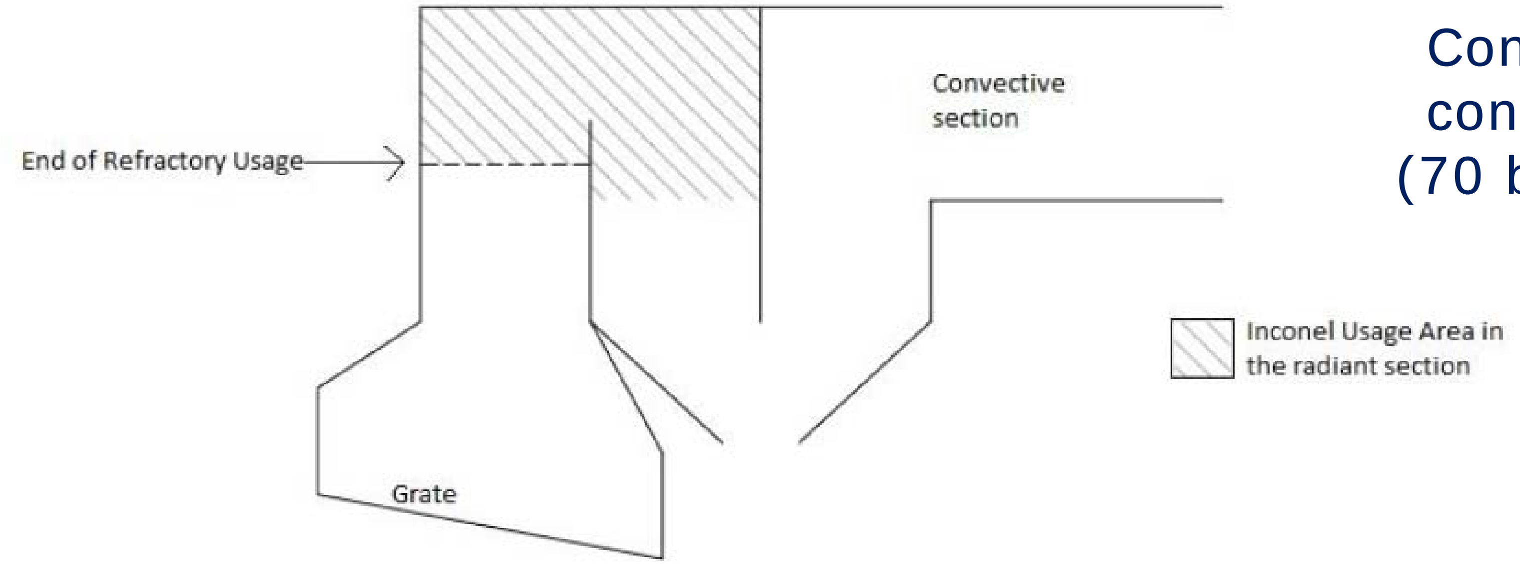
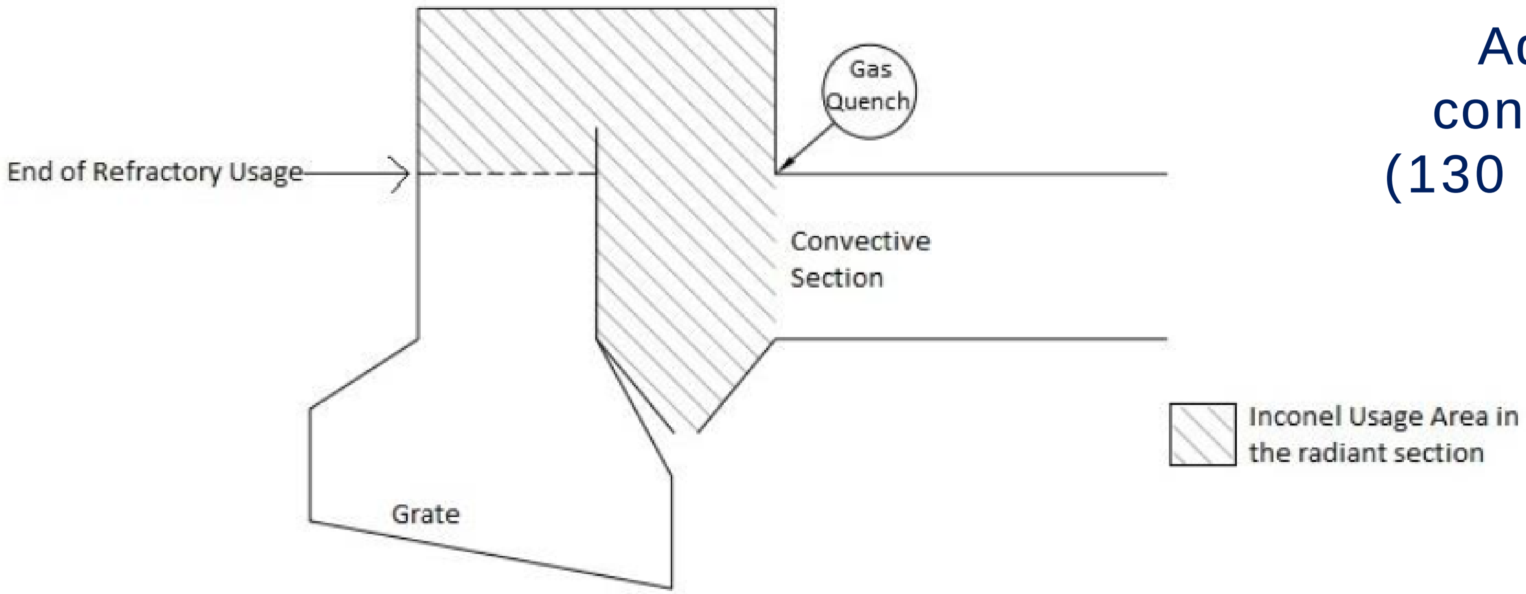
- Backup slides -

Boiler protected areas

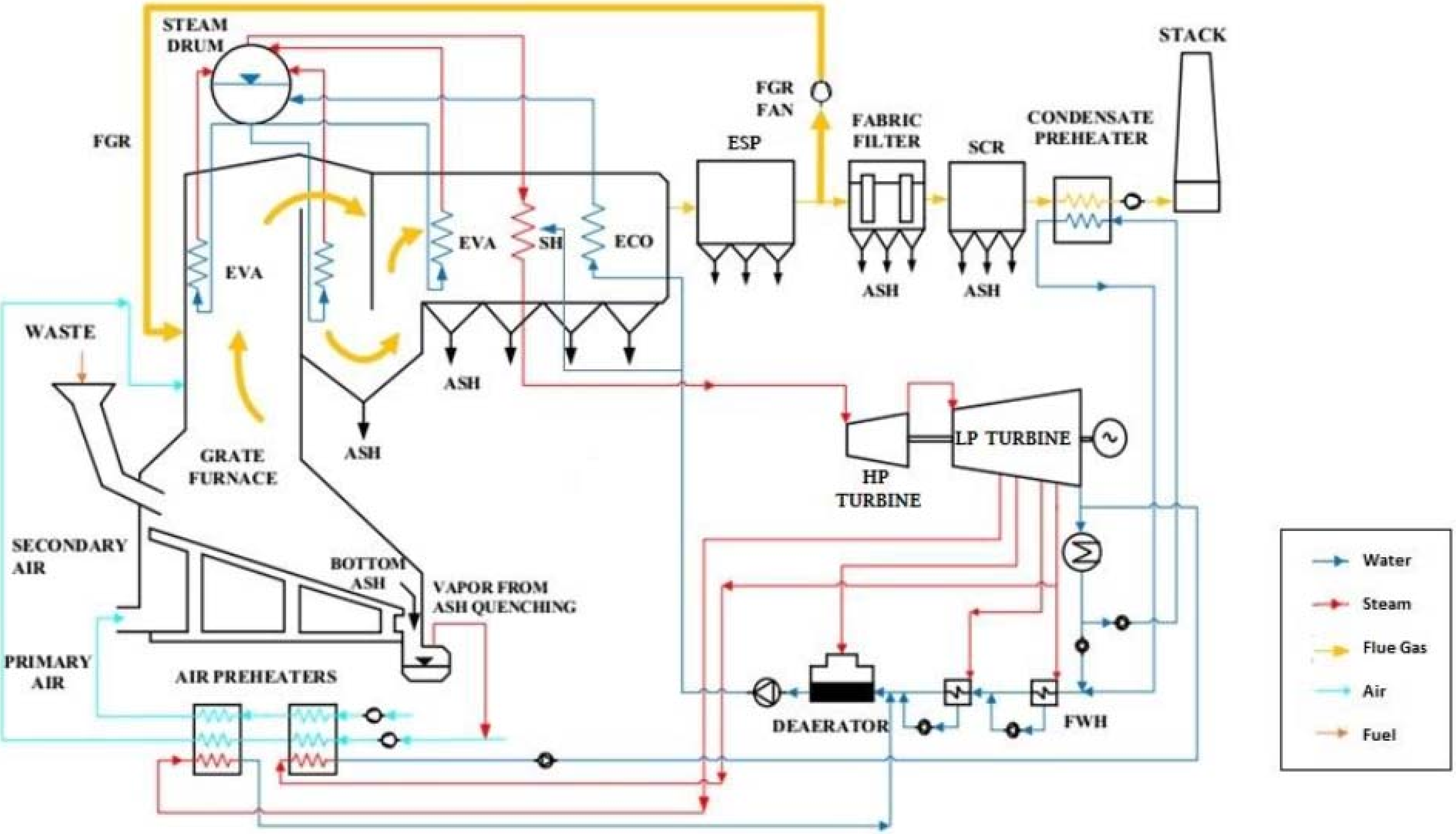


Conventional configuration (70 bar, no RH)

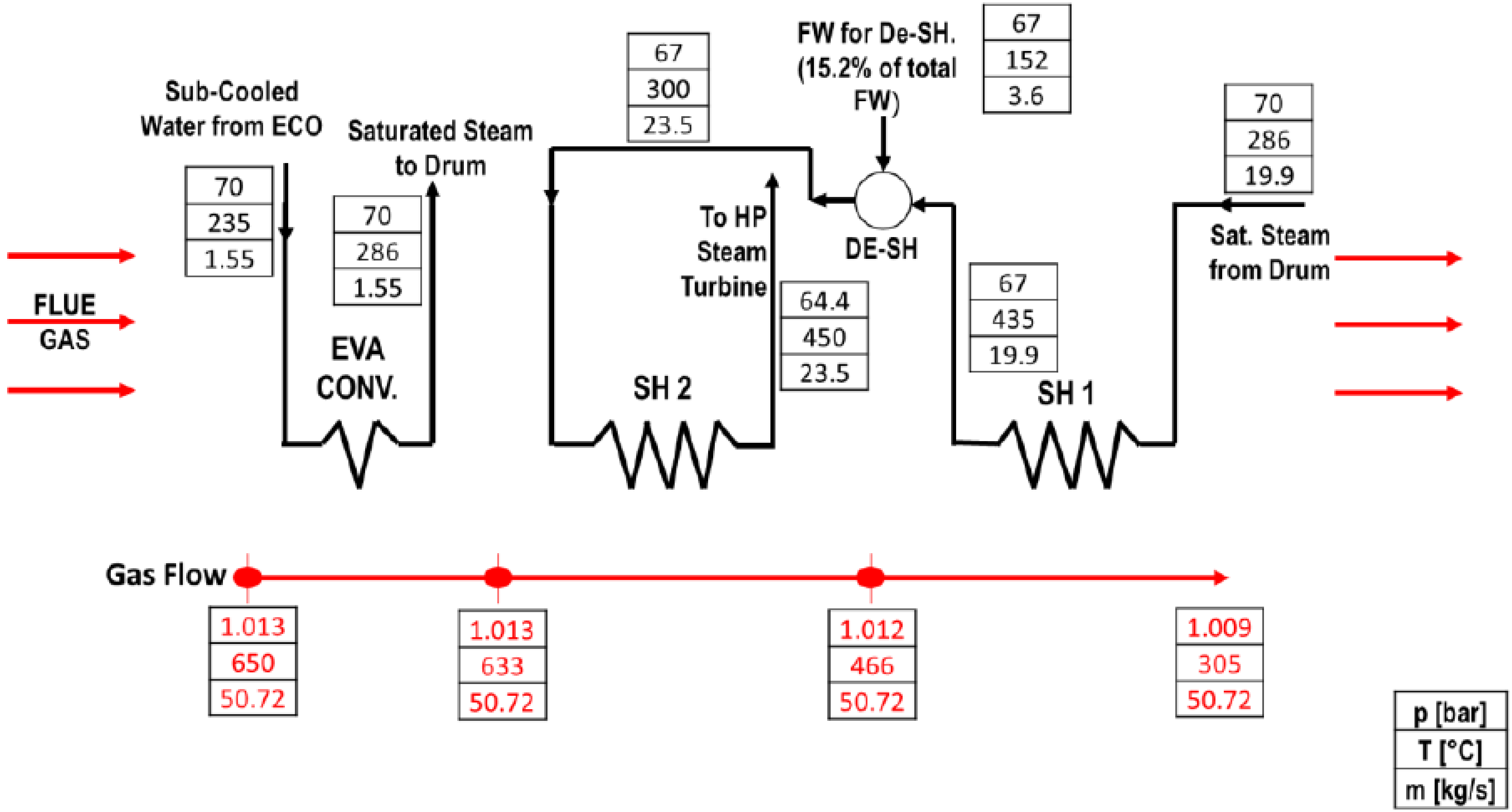


Advanced configuration (130 bar, w/ RH)

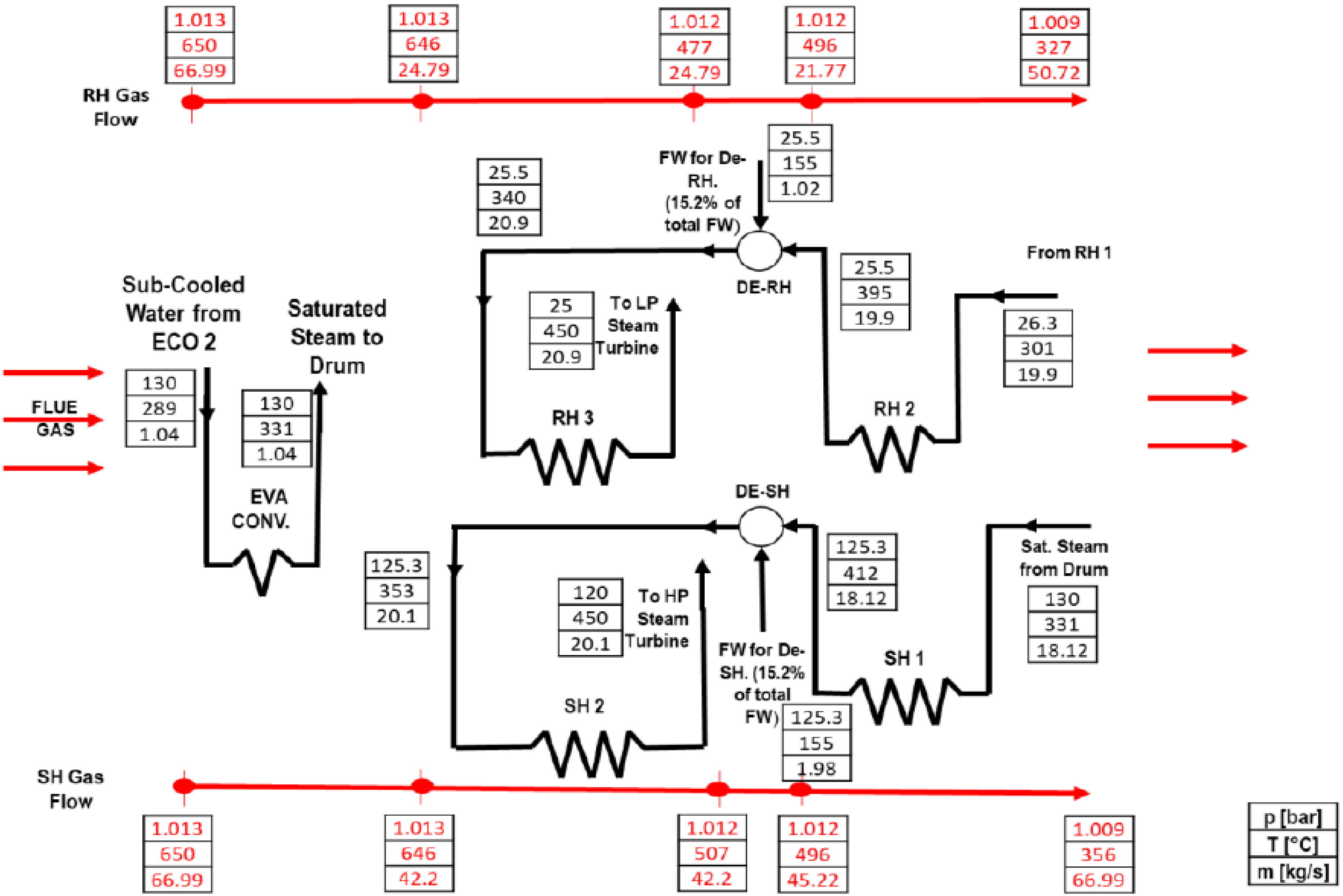
Conventional configuration



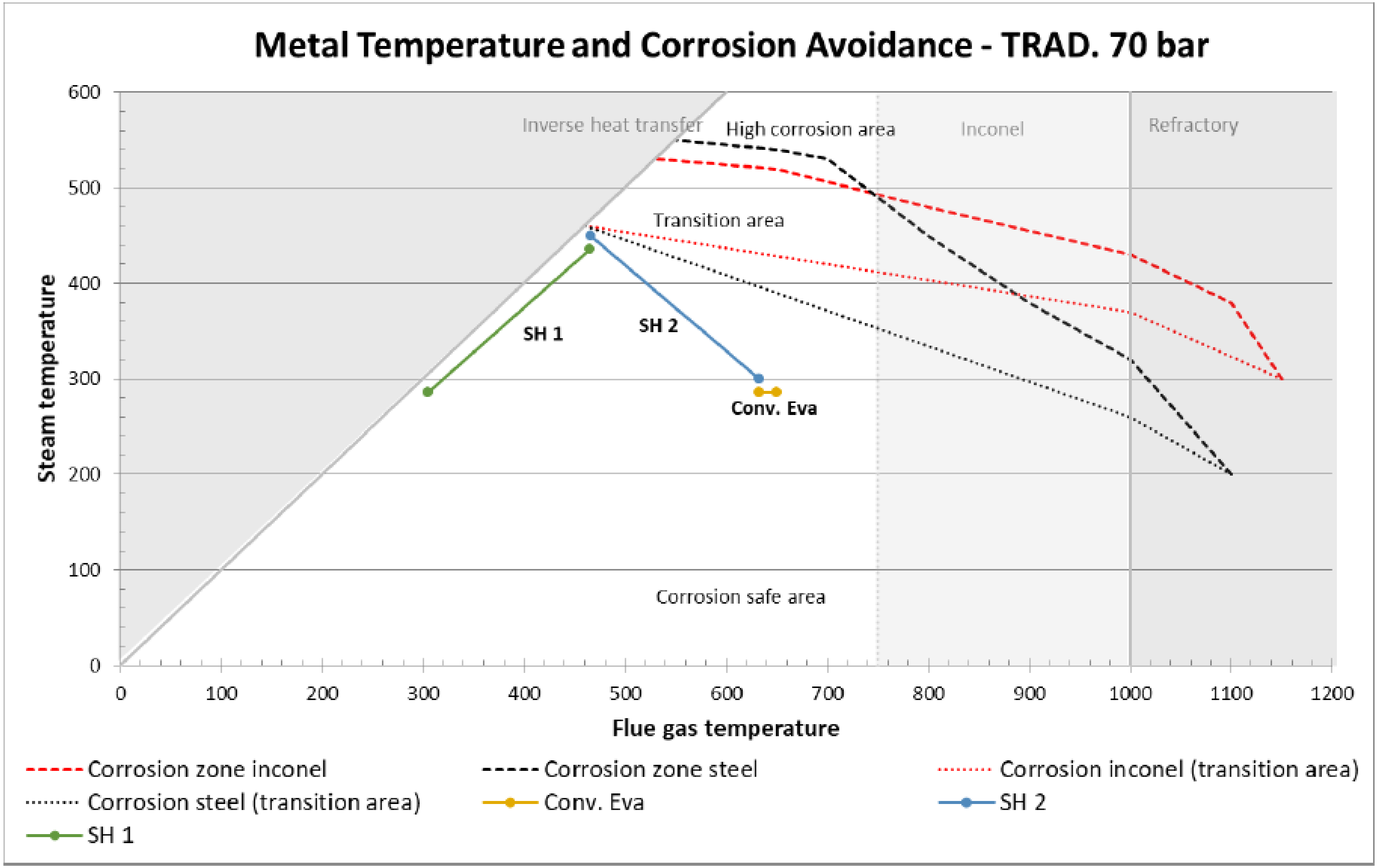
Steam SH - conventional configuration



Steam SH / RH - advanced configuration



Corrosion - conventional configuration



Corrosion - advanced configuration